Space Weather Technical Forecast

Issued on Tuesday, 13 February 2024 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrivals possible on 13 and 14 Feb, with G1/Minor Storm intervals likely and a chance of G2/Moderate Storms. M-flares expected, with a chance of X-flares. S1/Minor radiation storm likely to slowly decline.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Activity was Moderate with a peak long period M2.6 flare peaking at 12/2117 UTC was also seen from over the northeast limb. There are seven sunspot regions on the visible disc. AR3583, in the northeast quadrant has weakened, with the delta spot in the region no longer visible. AR3576 in the southwest is also weakening with a weak delta spot still visible. AR3582 is moderately complex but stable. The remaining visible regions are all unipolar and stable, but a region just beyond the northeast limb has exhibited CME and flare activity, and has the potential to be a significant region as it rotates onto the visible side of the Sun.
Two fast CMEs have been observed and analysed in the last 24 hours, one from the northwest and one from the northeast limb, but neither are forecast to have an Earth directed component.

Solar Wind / Geomagnetic Activity: Solar winds at L1 have followed a steadily declining trend from 500km/s down to around 425km/s. There as a brief increase due to a CME arrival at around 13/0200UTC but this did little to arrest the declining trend. Density initially increased modestly, reaching a peak of 16ppcc at 13/0616UTc, but has since declined to 5ppcc. Total magnetic field strength has been weak, but increased sharply to reach a peak of 6.13nT at 13/0300UTC following a weak CME arrival. Magnetic field strength has since remained elevated but still relatively weak. The north-south component started weakly positive, but switched to a weakly negative orientation at around 13/0200UTc due to the onset of the CME. Phi angle started mainly positive (away from the Sun), but has been mainly negative since 13/1900UTC. Geomagnetic activity has been Quiet throughout.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux has been above the S1/Minor Radiation Storm threshold throughout, and briefly increase above the S2/Moderate threshold between 13/0835UTC and 13/0915UTC, but has since followed a sustained declining trend. 100Mev proton flux briefly reached the 1pfu level between 12/1015-1430 UTC, but has since declined to around 0.5pfu.

GOES16 high energy (greater than 2MeV) electron flux remained mostly at background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold on a slight rising trend. The fluence at 13/0000UTC was 2.6e6 pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary
Solar Activity: Moderate activity is expected with further M-flares, and a chance of X-flares. These most likely from AR3576 in the southwest, or perhaps from the new region rotating onto the northeast limb.

Solar Wind / Geomagnetic Activity: There are three CMEs which may have Earth-directed impacts, two of which are potential glancing blows during 13 Feb, with a third more likely arrival late 13 Feb or into 14 Feb, but low confidence in the extent of any impacts. This has the potential to combine with the previous impacts, leading to a risk of enhanced response. Solar winds are then expected to gradually ease 15 Feb onward. There is a chance that the CME arrival observed early on 13 Feb was connected to one of these features.

Initially Quiet geomagnetic activity is likely. During 13 Feb and into 14 Feb with the potential CME arrivals, G1/Minor Storm intervals become likely with a chance of G2/Moderate Storms. Any combined impacts bring a slight chance of G3/Strong Storms. CME influence will then ease later 14 Feb and into 15 Feb, with activity becoming mainly Quiet by 16 Feb.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux is currently at 5pfu on a declining trend. Further enhancements are possible associated with potential CME arrivals on 13 or 14 Feb, along with any significant flares from AR3576. In the absence of further enhancements, proton flux is most likely to continue on a declining trend, likely falling back below the S1 threshold by 15 Feb.

High energy electron flux (greater than 2MeV) and the associated 24-hour electron fluence may rise later in the period after CME effects wane, with just a slight chance of reaching the Active threshold (1e8 integrated pfu) by the end of the period.

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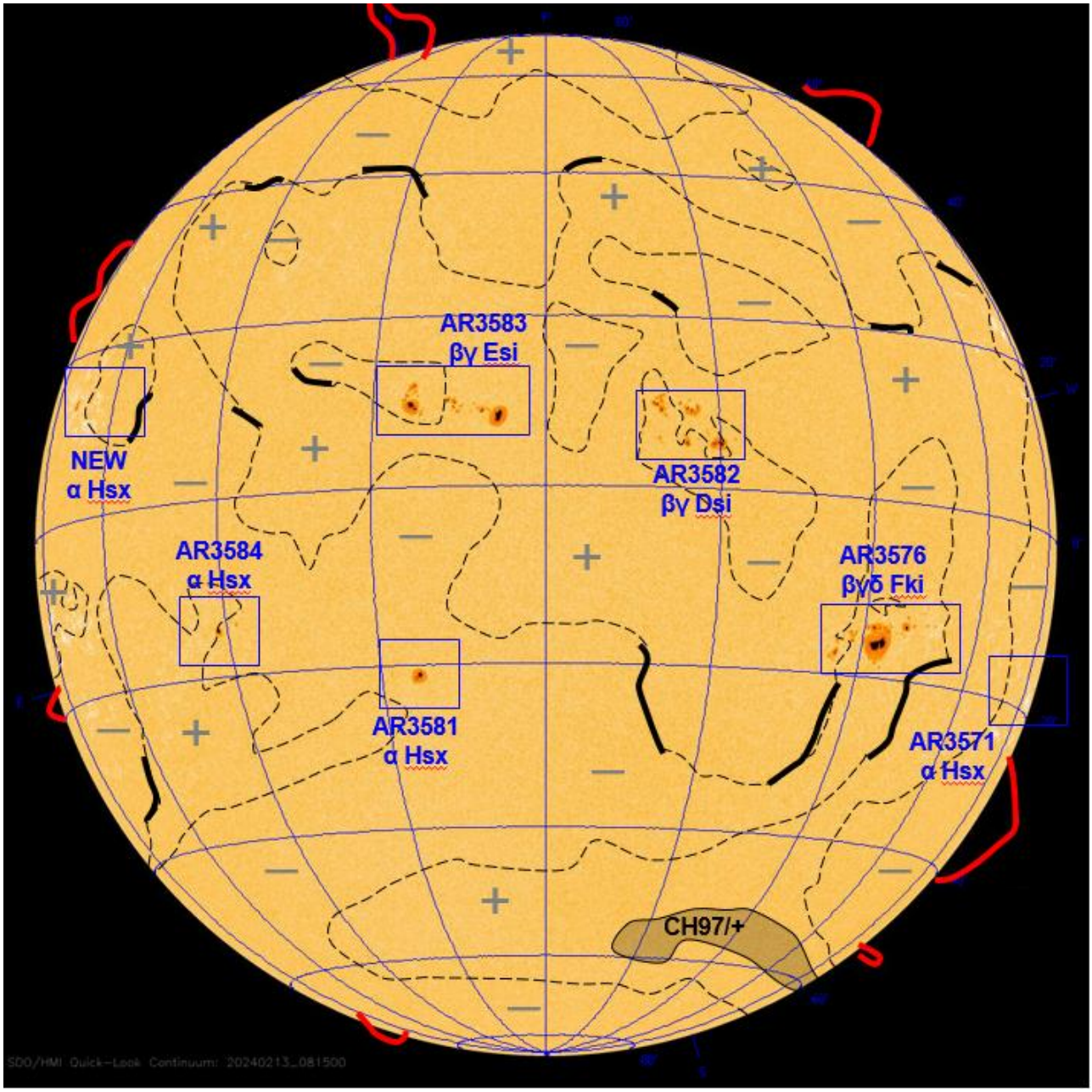
Figure 1. Solar Analysis Valid 13/0800UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Three CMEs are forecast to affect the Earth on 13 Feb. Firstly from a filament eruption on south-centre disc on 08 Feb, which was modelled to perhaps glance the Earth early on 13 Feb. An eruption on 10 Feb, is also forecast to have a possible Earth directed component, and as it is faster than the 08 Feb eruption, may combine with the previous CME. However, as both were forecast to glance the Earth, the probability of affecting the Earth are considered low. Finally, an eruption from the southwest quadrant late on 10 Feb, left the Sun in a northwest direction and may arrive at Earth later on 13 Feb. This is considered to be the most likely feature to arrive at Earth, but also contains inherent uncertainties in the forecast which mean it could combine with the two previous features and create a larger impact with a decreasing risk of missing the Earth entirely.

Also under consideration is a recent CME arrival late on 12 Feb, which has not been attributed to any particular event, but could be one of the three mentioned above. The impacts of this arrival have been muted with no further effects expected from this particular arrival.
No coronal hole impacts are forecast through the next four days, with coronal hole 97 considered too far south to affect the Earth. Solar winds may become elevated due to any CME arrivals, but otherwise should be around slightly elevated or ambient levels.
Geomagnetic activity is forecast to reach Active or G1/Minor Storm levels on 13 Feb and perhaps into 14 Feb, with a lower risk of G2/Moderate Storms. There is also a lower risk of G3/Strong Storms, if all three CMEs combine and affect the Earth. There is then a decreasing risk of geomagnetic storming as the forecast period progresses.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	70	40	5	1
Strong	G3	No	15	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
10/1040	Nil	Filament eruption	South Centre	890 km/s	13 Feb	Glancing blow possible
11/0330	Nil	Filament eruption	SW directed NW	810lm/s	13 Feb	Complex eruption- low confidence

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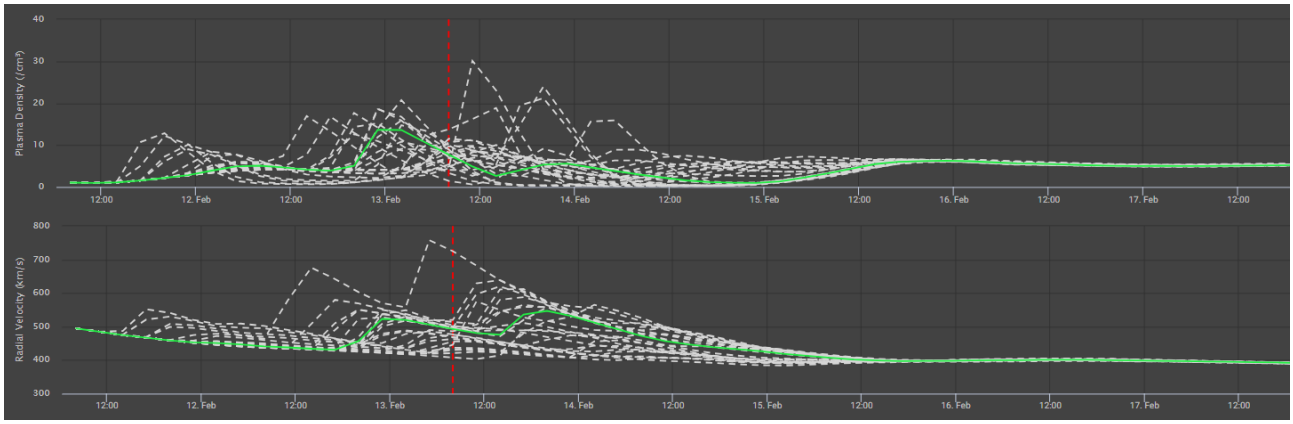
Figure 2: L1 Solar wind data with the CME arrival clearly visible.

Figure 3: MOSWOC Enlil ensemble



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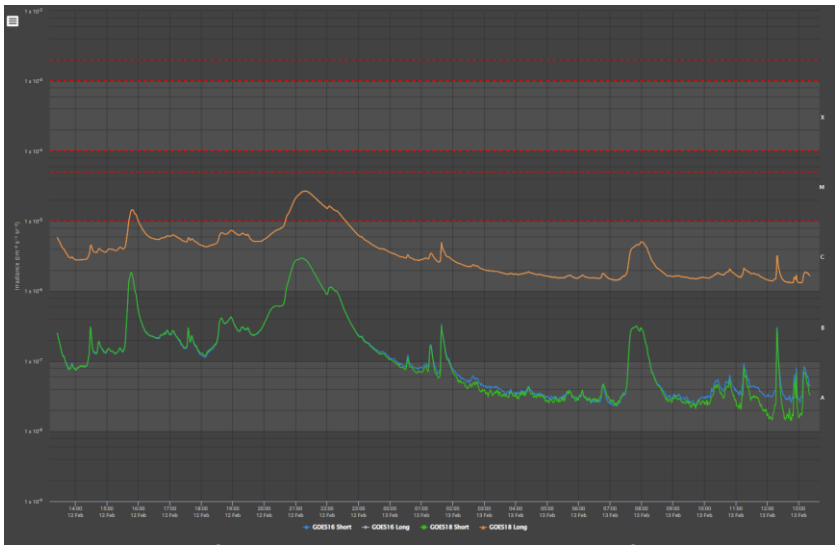
Radio Blackouts - X-Ray Flares:
Solar activity has been Moderate, with a peak flare of M2.6 from a region which is beginning to become visible from over the northeast limb. AR3576 and AR3583 have both had a history of significant flare activity and high complexity. AR3583 has seen a delta spot fade over the last 24 hours, with the delta spot in AR3576 also beginning to fade. AR3582 appears complex, but has not yet produced significant flare activity. The region close to the northeast limb, appears to be active based on a recent CME and the complexity visible in the magnetic looping above the region.

Further M-class flares are expected, especially from AR3576 and AR3583 but increasingly from the region beyond the limb. On balance the slightly decreasing risk from AR3576 is balanced by the risk from the new region on the northeast limb, resulting in a level trend for the risk of solar flares through the next four days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	70	70	70
Very Active	R3 to R5 X Class	No	20	15	15	15

Figure 4: GOES 16 X-ray flux



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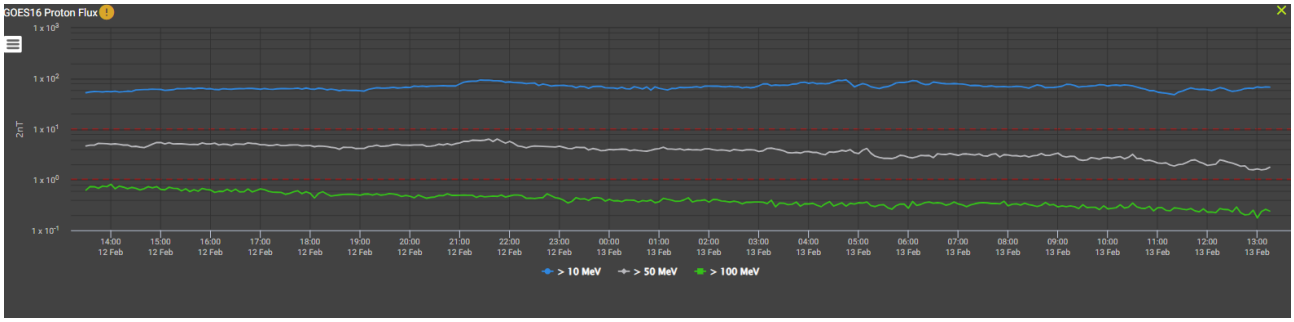
Solar Radiation Storms - (High Energy Protons):
GOES 18 high energy (greater than 10MeV) proton flux has been enhanced due to a number of proton rich flares and CMEs from the farside and just beyond the southwest limb. The S1 level has been consistent through the last 24 hours, with a brief rise to the S2 level, most likely due to an eruption from just beyond the northeast limb early on 13 Feb. The flux now appears to be trending downwards, but this decrease could be slowed due to CME arrivals which are forecast through 13 and 14 Feb, or due to further high energy flares. Based on current trends proton flux is forecast to fall below the S1 level by the 15 Feb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	70	40	20
Very Active	**≥ S3 ***	No	10	10	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES 18 proton flux



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High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) is at background and is forecast to be at this level in the absence of any CME arrivals. If a CME or combination of CMEs arrive, then after an initial decline due to distortion of belts and increased geomagnetic activity, there is a possibility of a sharp rise to moderate and perhaps high levels later in the period. This is likely to be due to radiation belts relaxing into natural orbits and spacecraft at GEO detecting the increased electron populations from the CMEs that have become trapped in the radiation belts.

Associated 24 hour hour electron flux is expected to remain well below the Active (1e8 integrated pfu) threshold, but with an increasing trend towards the end of the period due to any inputs from CME arrivals.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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